PAYLOAD FLIGHT HAZARD REPORT				a. NO:	AMS-02-F11
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)			c. PHASE:	II
d. SUBSYSTEM:	Structural, Mechanical	e. HAZARD GROUP:	Impact, Collision	f. DATE:	May 22, 2006
g. HAZARD TITLE:	Mechanism Failure			i. HAZARD CATEGORY:	CATASTROPHIC X CRITICAL
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B and ISS Addendum, 200.1, 200.2, 200.3				
j. DESCRIPTION OF HAZARD:	AMS-02 relies on a number of mechanisms to successfully complete the planned mission profile. Failure of these mechanisms could limit the AMS-02's ability to complete its mission. Additionally failure of these mechanisms could place the AMS-02 in conditions that pose a risk of inadequate structural load conditions or damage to vehicle systems.				

k. CAUSES

(list)

1. Inability to Open/Close Orbiter Payload Retention Latch Assembly (PRLA)/ Keel Latch.
2. Inability to Operate the ROEU.
3. Improper Installation of Grapple Fixtures.
4. Inability to fully capture/release the Payload Attach System, including the UMA.
5. Inadvertent release of Payload Attach System EVA Release Mechanism.
6. Inability to secure ROEU Support Structure.
7. Improper Installation of BCS

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F11
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

l. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)	OPS CONTROL
1. CAUSE: Inability to Open/Close Orbiter Payload Retention Latch Assembly (PRLA).	
1.1 CONTROL: The AMS-02 interface to the PRLAs, the Trunnions, Scuff Plates and keel pin are constructed and installed in accordance with NSTS 21000-IDD-ISS. Trunnions and keel pin are constructed of custom 455 stainless steel and the scuff plates are constructed of aluminum 7050. 1.1.1 SVM: Review of design 1.1.2 SVM: Inspection of as built hardware 1.1.3 SVM: PRLA fit check during AMS-02 Installation into Orbiter 1.1.1 STATUS: Open 1.1.2 STATUS: Open 1.1.3 STATUS: Open	
1.2 CONTROL: In the event that one or more Orbiter PRLA is unable to open during the AMS-02 deploy sequence, the AMS-02 is designed to be compatible with an unscheduled EVA to open/close the PRLAs. AMS-02 hazard report AMS-02-F14 indicates the constraints to EVA activities; none of these no touch/keep out zones will impact the ability of the crew to access the PRLAs for EVA operations. The unscheduled EVA to open/close PRLA is a standardized EVA operation for the Shuttle, no unique operations are required for the AMS-02. 1.2.1 SVM: Review of design. 1.2.2 SVM: Inspection of as built hardware. 1.2.1 STATUS: Open 1.2.2 STATUS: Open	
1.3 CONTROL: The AMS-02 is safe to return only with all PRLAs and the Active Keel (latch) Assembly closed. A flight rule will be in place that the AMS-02 can only return with this safe configuration. In the event that any latches cannot be closed either electrically or by EVA, the AMS-02 will have to be returned to be berthed upon the ISS until an Orbiter with working latches is available to return the vehicle. 1.3.1 SVM: SVM: Structural Analysis to confirm safe return configuration of PRLA and KEEL latches.	S

1.3.2 SVM: Review of Flight Rules 1.3.1 STATUS: Open 1.3.2 STATUS: Open	
NOTE: Nominal generic flight rules for PRLA/AKA operations (A10-281) are all applicable for the AMS-02.	
2. CAUSE: Inability to Operate the ROEU.	
2.1 CONTROL: In the event that the ROEU fails to separate, the AMS-02 can support an unscheduled EVA to access the ROEU EVA interfaces to either disengage or reengage the ROEU. 2.1.1 SVM: Review of Design. 2.1.2 SVM: Inspection of as built hardware. 2.1.1 STATUS: Open 2.1.2 STATUS: Open	
2.2 CONTROL: The inability to reattach the ROEU will not create a scenario where a hazardous condition will exist for the AMS-02 or the Orbiter, however there is a damage potential for AMS-02 scientific hardware that will preclude its reuse (Mission Success Only). If possible the use of an unscheduled EVA to reattach the ROEU is encouraged, but not required. 2.2.1 SVM: Review of design to confirm no safety impact to loss of power and communication for return configuration. 2.2.1 STATUS: Open	
2.3 CONTROL: The installation of the AMS-02 passive half of the ROEU is designed to be compatible with the requirements of NSTS 21000-IDD-ISS for alignment, strength and deflection. 2.3.1 SVM: Review of design. 2.3.2 SVM: Inspection of as built hardware. 2.3.3 SVM: Structural Analysis. 2.3.1 STATUS: Open 2.3.2 STATUS: Open 2.3.3 STATUS: Open	

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F11
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

3. CAUSE: Improper Installation of Grapple Fixtures.	
3.1 CONTROL: Grapple fixtures are located and mounted in accordance with NSTS 21000-IDD-ISS for clearances, mass, CG offset and visibility. Grapple fixture locations have been selected to facilitate the exchange of the AMS-02 between SRMS and SSRMS and SSRMS berthing activities. 3.1.1 SVM: Review of design. 3.1.2 SVM: Inspection of as-built hardware. 3.1.1 STATUS: Open 3.1.2 STATUS: Open	
4. CAUSE: Inability to fully capture/release the Payload Attach System, including the UMA.	
4.1 CONTROL: The AMS-02 passive half of the Payload Attach System (PAS), including the UMA interface has been built to comply with the requirement of SSP57213 (AMS-02 to ISS ICD) and through the ICD, SSP 57003 and SSP 57004. 4.1.1 SVM: Review of design. 4.1.2 SVM: Inspection of as-built hardware. 4.1.3 SVM: AMS-02 PAS interface testing between flight Passive (AMS-02) and flight Active (ISS) components. 4.1.4 SVM: UMA electrical Connectors verified to be mechanically and electrically compatible across the UMA interface. 4.1.5 SVM: AMS-02 will be tested prior to installation into the Orbiter on the Active Common Attach System Simulator (ACASS) to confirm proper mating and interface. 4.1.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0001, “Mechanical Design of the Payload Attach System (PAS)”, Dated 8 January, 2006 from AMS-02 Chief Engineer. 4.1.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0003, “Quality Inspection of the Payload Attach System” dated 03 March 2006, from AMS-02 Chief Engineer Chris Tutt. 4.1.3 STATUS: Closed. On March 10-11, 2003, PAS was placed in position on S3 truss (flight) and capture claw was fully closed and reopened three times. All mechanical interfaces operated successfully. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, “Functional Testing of the Payload Attach System (PAS)”, dated 28 December 2005 from AMS-02 Chief Engineer Chris Tutt.	

4.1.4 STATUS: Open

4.1.5 STATUS: Open

4.2 CONTROL: The AMS-02 passive interface to the Payload Attach System includes an EVA release mechanism capable of releasing the stored energy of the maximum preload of 6430 lbs and removing the capture bar to release the AMS-02 from the ISS. EVA operated, screw driven ramps release the preload created by the capture of the Passive PAS capture bar. Once the loads are released, an EVA release bar allows for the extraction of the capture bar from the Active PAS.

4.2.1 SVM: Review of Design.

4.2.2 SVM: Inspection of as-built hardware.

4.2.3 SVM: Functional testing of the EVA Release mechanism.

4.2.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0001, "Mechanical Design of the Payload Attach System (PAS)", Dated 8 January, 2006 from AMS-02 Chief Engineer.

4.2.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0003, "Quality Inspection of the Payload Attach System" dated 03 March 2006, from AMS-02 Chief Engineer Chris Tutt.

4.2.3 STATUS: Closed. On February 12-14, 2003, the PAS capture bar release mechanism was successfully used to release the loaded PAS as part of the general PAS qualification testing. On March 10-11, 2003, the PAS was placed in position on S3 truss (flight) with the capture claw fully closed and the capture bar mechanism was also successfully used to release the loaded PAS. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December 2005 from AMS-02 Chief Engineer Chris Tutt.

4.3 CONTROL: To assure that the appropriate preload is present when the AMS-02 is interfaced with the active PAS, a travel limiting screw is adjusted prior to flight to provide the appropriate placement of the capture bar, utilizing the 10° ramp to raise and lower the capture bar. When positioned correctly the capture position of the latch and the required displacement of the bar generated the preload. This travel limiter allows for the EVA crew to readily replace the capture bar once it is removed and make the passive PAS of the AMS-02 capable of being installed in a functioning active PAS.

4.3.1 SVM: Review of Design

4.3.2 SVM: Inspection of as built hardware.

4.3.3 SVM: Functional testing of preload set travel limiter.

4.3.4 SVM: Final setting/check of preload position of latching bar.

4.3.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0001, "Mechanical Design of the Payload Attach System (PAS)", Dated 8 January, 2006 from AMS-02 Chief Engineer.

4.3.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0003, "Quality Inspection of the Payload Attach System" dated 03 March 2006, from AMS-02 Chief Engineer Chris Tutt.

4.3.3 STATUS: Closed. During integration testing with S3 Truss February 12-14, 2003 and March 10-11, 2003 travel limiters were confirmed. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December

4.3.4 STATUS: Open

5. CAUSE: Inadvertent release of Payload Attach System EVA Release Mechanism.

5.1 CONTROL: To release the AMS-02 from the ISS PAS the EVA Releasable Capture Bar must be withdrawn from the latched PAS mechanism. Once latched, the preload generated by the capture event and the design of the AMS-02 is 5650 lbs nominal/6430 lbs maximum to prevent gapping of the AMS-02. To relieve this load, two independent load relief devices must be operated to drive apart two wedges. The sliding of these wedges apart releases the energy of the interface and lowers the guides through which the capture bar runs. The capture bar cannot be extracted due to interference with the alignment brackets that lock the capture bar in place until the bar is lowered by each of the load relief devices. Each EVA Load Release Screws have a separate spring operated lock to preclude the 7/16th inch EVA bolt head from turning until depressed by the EVA tool.

Thus to release the AMS-02 from the PAS by fault, the following must occur:

- Failure of first EVA Load Release Screw locking mechanism
- Fault operation of first EVA Load Release Screw and wedges to release the 5650 lb (nominal) preload and lower the guides
- Failure of second EVA Load Release Screw locking mechanism
- Fault operation of second EVA Load Release Screw and wedges to release the 5650 lb (nominal) preload and lower the guides
- Fault extraction of the EVA Releasable Capture Bar from PAS latch.

5.1.1 SVM: Review of Design. 5.1.2 SVM: Inspection of as built hardware. 5.1.3 SVM: Functional testing of EVA Release Mechanism, 5.1.4 SVM: Final setting/check of travel limiter for release position. 5.1.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0001, "Mechanical Design of the Payload Attach System (PAS)", Dated 8 January, 2006 from AMS-02 Chief Engineer. 5.1.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0003, "Quality Inspection of the Payload Attach System" dated 03 March 2006, from AMS-02 Chief Engineer Chris Tutt. 5.1.3 STATUS: Closed. On February 12-14, 2003, the PAS capture bar release mechanism was successfully used to release the loaded PAS as part of the general PAS qualification testing. On March 10-11, 2003, the PAS was placed in position on S3 truss (flight) with the capture claw fully closed and the capture bar mechanism was also successfully used to release the loaded PAS. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December 2005 from AMS-02 Chief Engineer Chris Tutt. 5.1.4 STATUS: Open Initial testing of travel limit positions occurred during PAS integration testing with S3 Truss.	
5.2 CONTROL: The AMS-02 will be restrained by the SSRMS prior to any EVA operations to release the PAS interface to preclude being a released, uncontrolled mass. 5.2.1 SVM: Review of Crew Procedures 5.2.1 STATUS: Open	I
5.3 CONTROL: The Capture Bar is design to preclude a complete release of the bar by a physical interference to complete extraction from the support structure. If not reinstalled and put to "preload" position, the capture bar design is such to allow for safe return without release. 5.3.1 SVM: Review of design. 5.3.2 SVM: Inspection of as built hardware. 5.3.3 SVM: Structural analysis of "released" position of capture bar without return to "preload" position. 5.3.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0001, "Mechanical Design of the Payload Attach	

System (PAS)", Dated 8 January, 2006 from AMS-02 Chief Engineer.

5.3.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0003, "Quality Inspection of the Payload Attach System" dated 03 March 2006, from AMS-02 Chief Engineer Chris Tutt.

5.3.3 STATUS: Open

5.4 CONTROL: The AMS-02 will maintain the SSP 57003 required stiffness of the AMS-02 to ISS interface by accurately positioning the AMS-02 PAS Capture Bar during ground processing prior to flight. Preflight testing has established the proper spring constant required to exceed the required stiffness and the AMS-02 PAS is configured specifically to provide this stiffness capability. When the capture bar is lowered, this stiffness is reduced. The AMS-02 is equipped with anti-rotation devices to preclude the wedge drive screws from backing out. Although structurally isolated from significant vibrational and acoustic loading, the design of the anti-rotation device was analyzed to establish its sensitivity to directly applied random vibrational loads. The natural frequency of the anti-rotation device, based on the spring constant of the design, is 36.6 Hz. The design of the anti-rotation device requires a compressive force of 4.88 lbs. A maximum acceleration of the induced random vibrations at 36.6 Hz generates a acceleration of 4.79g, resulting in an applied force of 0.63 lbs to the anti-rotation device. Using the maximum Power Spectral Density level anywhere (well outside what is possible for this equipment), the maximum applied force of 1.58 lb is calculated (again assuming direct application of the loads) This is a factor of three less than that required to depress the anti-rotation device even if the structure of the AMS-02 did not attenuate the transmission of these random loads to the mechanisms..

Given that the design of the anti-rotation device did not preclude the rotation, the drive screws have a measured minimum running torque of 3 in-lbs that would resist rotation and a minimum "break" torque of 5 in-lbs. Assuming that the anti-rotation devices can be overcome or experience failure, and the rotation of the drive shafts were to occur, to lose the preload of the AMS-02 passive PAS to the ISS active PAS, the shafts driving the wedges that support the capture bar must rotate through a minimum of 12.7 rotations. Given that the exposure to a vibration load (again ignoring the attenuation of the AMS-02 structure that essentially makes the forces at the anti-rotation mechanism insignificant) lasts for approximately 20 seconds, the statistical probability to rotate the shafts sufficiently during launch to reposition the capture bar to reduce the stiffness/preload to below the SSP 57003 allowable is 10^{38} to 1 against or 5.877×10^{-39} chance.

No mechanism for removal of preload have been identified as credible for any other mission phase.

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F11
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

5.4.1 SVM: Preflight Inspection for proper configuration of preload mechanism.
5.4.2 SVM: Analysis of anti-rotation devices on EVA Release Mechanism of AMS-02 PAS.
5.4.3 SVM: Testing of EVA Release Mechanism for Breaking Torque and Running Torque.
5.4.4 SVM: Analysis of AMS-02 Preload to rotation of EVA Release Mechanism drives.
5.4.5 SVM: Approval of ISS Mechanism Working Group/Mechanical Systems Working Group.

5.4.1 STATUS: Open
5.4.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0017
5.4.3 STATUS: Closed. Memo TBD
5.4.4 STATUS: Closed. Memo TBD
5.4.5 STATUS: Open

Note: ~~The inability to release from the ISS after two faults ((1)PAS and (2)AMS-02 EVA Release Mechanisms) is not considered a catastrophic condition. AMS-02 is still securely attached to the ISS.~~ISS requirements imposed on the AMS-02 and other external payloads to attach to the PAS only require that a means of EVA release from the PAS be provided, not that the release be multiply fault tolerant. The AMS-02 PAS EVA Release mechanism is designed to be zero-fault tolerant in its operation and not represent a multiple fault tolerant approach through out design for minimum risk.

6. CAUSE: Inability secure ROEU Support Structure.

Note: The AMS-02 EVA operation to rotate the ROEU Support Structure to maximize the distance between the AMS-02 and the adjacent PAS payload envelope is a contingency operation that will only be performed if required by the specific installation of an adjacent payload or ISS Logistics Carrier.

6.1 CONTROL: The AMS-02 ROEU Support Structure has been designed to reduce the protrusion of the ROEU from the SSP 57003, 3.1.3.1.1.1 defined payload envelope. Magik Analysis of the extended (worst case protrusion) of the ROEU from the AMS-02 indicates that there is a 1.5 inch margin from the ROEU and the worst case displaced (translation and rotation) SSRMS installation of a full size payload next to the AMS-02. The ROEU Support Structure folding mechanism has been design to increase this margin. As a margin exists to contact/collision without the folding mechanism being

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F11
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

operated, it has been considered NON-SAFETY CRITICAL for operation.

6.1.1 SVM: Review of Design

6.1.2 SVM: Installation testing of AMS-02 PAS interface on flight hardware confirming AMS-02 berthing accuracy and by extension, positional accuracy of the ROEU.

6.1.3.SVM: Geometric Analysis of Installation Process (MAGIK)

6.1.4 SVM: Inspection of as built hardware for AMS-02 Geometry compliance

6.1.1 STATUS: Open

6.1.2 STATUS: Closed. Tests conducted February 12-14, 2003 and March 10-11, 2003. Test results are discussed in detail in ATA Reports 53013 and 53013A respectively.

6.1.3 STATUS: Closed. Published MAGIK Analysis Action Item #1705 Report dated May 12, 2003

6.1.4 STATUS: Open

6.2 CONTROL: Once operated, the AMS-02 ROEU Support Structure Folding Mechanism is capable of surviving all loads (launch being excluded) with only a single fastener (MSWG Approved Dual Action Pip Pins) of two being installed. The Pip Pins used are Avibank Spec 56789 Double Acting Ball-Lok (Space) Pin. These EVA compatible pins are design for minimum risk per MA2-00-057 and are single fault tolerant to inadvertent operation. Note: Hard stops exist at each alignment location for the pip pins to ease installation and not over extend its rotation. The hard stop is designed to handle all expected nominal and contingency loading (addressed as part of the structural margins).

6.2.1 SVM: Review of Design

6.2.2 SVM: Structural Analysis of Single Pin Configuration for subsequent loads.

6.2.3 SVM: Approval of DFMR criteria compliance by JSC/MSWG

6.2.4 SVM: EVA Worksite Analysis for mechanical systems operability.

6.2.1 STATUS: Open

6.2.2 STATUS: Open

6.2.3 STATUS: Open

6.2.4 STATUS: Open

7. CAUSE: Improper Installation of BCS

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F11
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

7.1 CONTROL: The BCS is installed and aligned to allow for proper alignment of the AMS-02 to the ISS PAS location during berthing operations per SSP 57003.

7.1.1 SVM: Review of Design

7.1.2 SVM: Inspection of BCS Installation on Flight hardware

7.1.3 SVM: Alignment testing of BCS to PAS passive hardware mounted to AMS-02

7.1.1 STATUS: Open

7.1.2 STATUS: Open

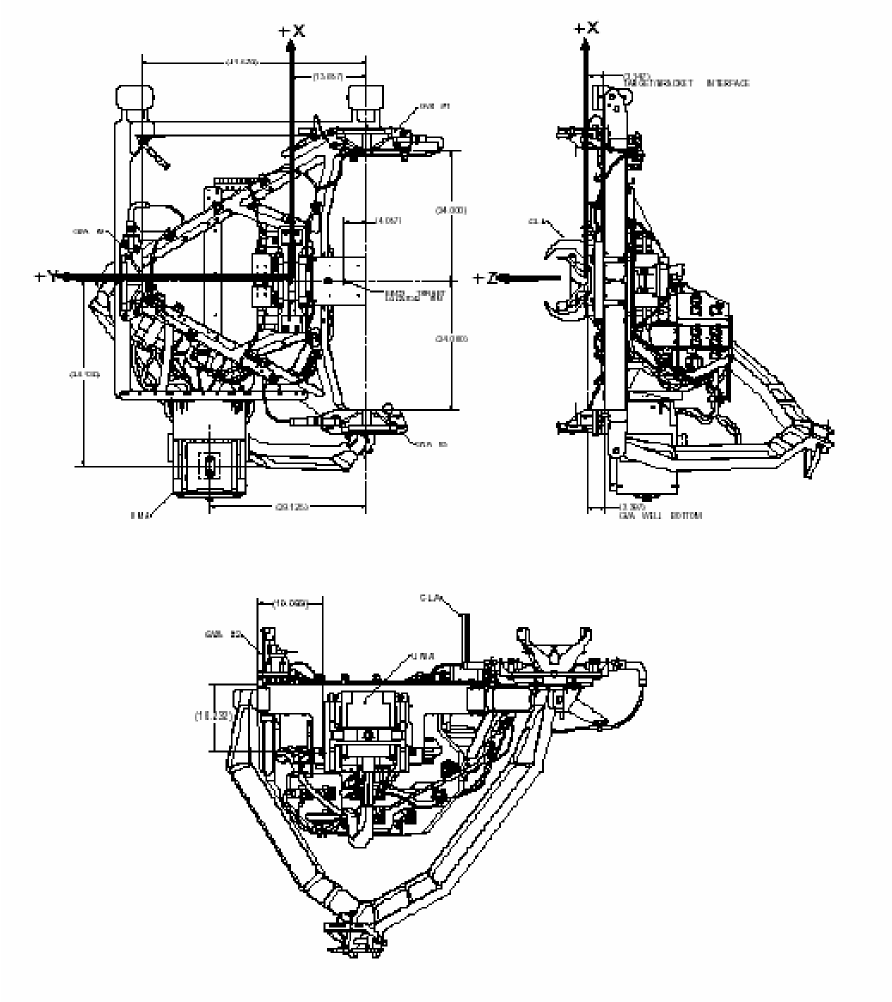
7.1.3 STATUS: Open

Notes:

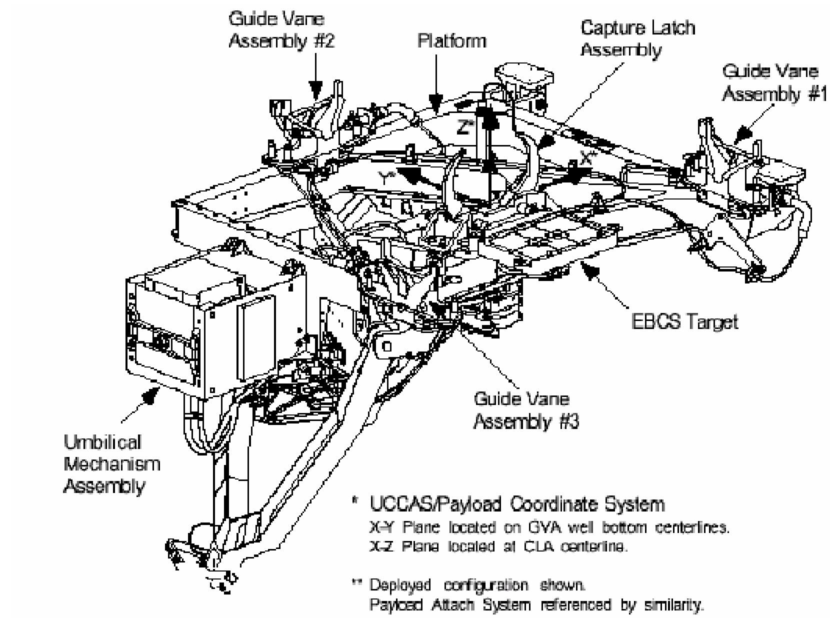
ACRONYMS	
ACASS – Active Common Attach Site Simulator	PAS – Payload Attach System, Payload Attach Site
AKA – Active Keel Assembly	PRLA – Payload Retention Latch Assembly
AMS-02 – Alpha Magnetic Spectrometer - 02	ROEU – Remotely Operated Electrical Umbilical
BCS – Berthing Camera System	SRMS – Shuttle Remote Manipulator System
DFMR – Design for Minimum Risk	SSRMS – Space Station Remote Manipulator System
EVA – Extravehicular Activity	SVM – Safety Verification Method
MSWG – Mechanical Systems Working Group	UMA – Umbilical Mating Assembly

Mechanisms Associated With the AMS-02

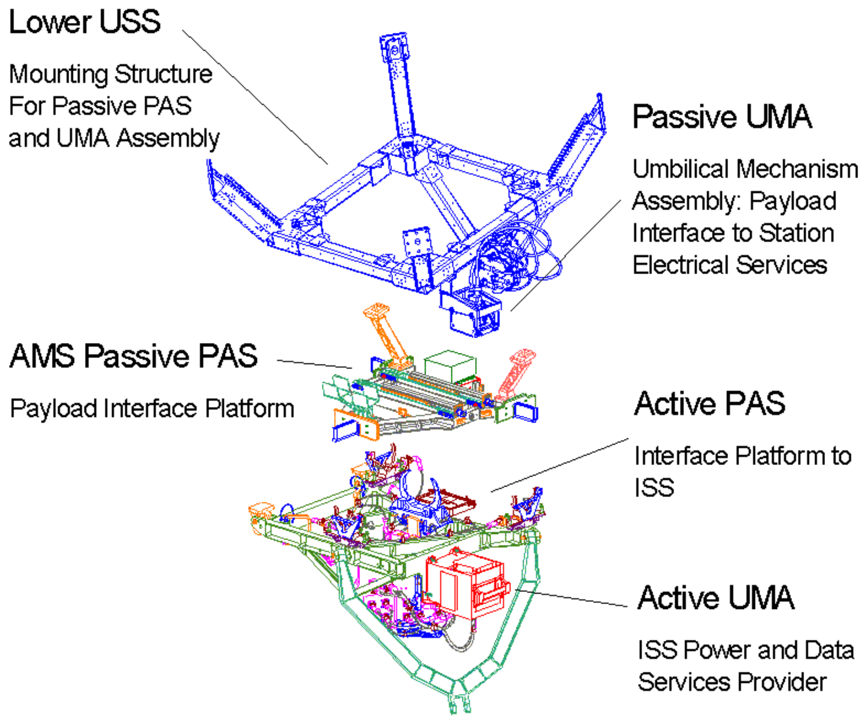
Mechanisms	Type	Operated by
Orbiter PRLA	GFE	Electrical/EVA
Orbiter Keel Latch	GFE	Electrical
Orbiter ROEU	GFE	Electrical/EVA
SRMS Grapple Fixture (FRGF)	GFE	Physical Interface to SRMS, EVA Release Capable
SSRMS Grapple Fixture (PVGF)	GFE	Physical Interface to SSRMS, EVA Release Capable
Active Payload Attach System	ISS System/GFE	Electrical
EVA Releasable Passive Payload Attach System	Payload Hardware	Passive interface to ISS. EVA interfaces (two preload relief interfaces and Capture Bar retraction)
UMA Interface	GFE	Electrical, EVA
AMS-02 ROEU Support Structure Folding Mechanism	Payload Hardware	EVA Crew.



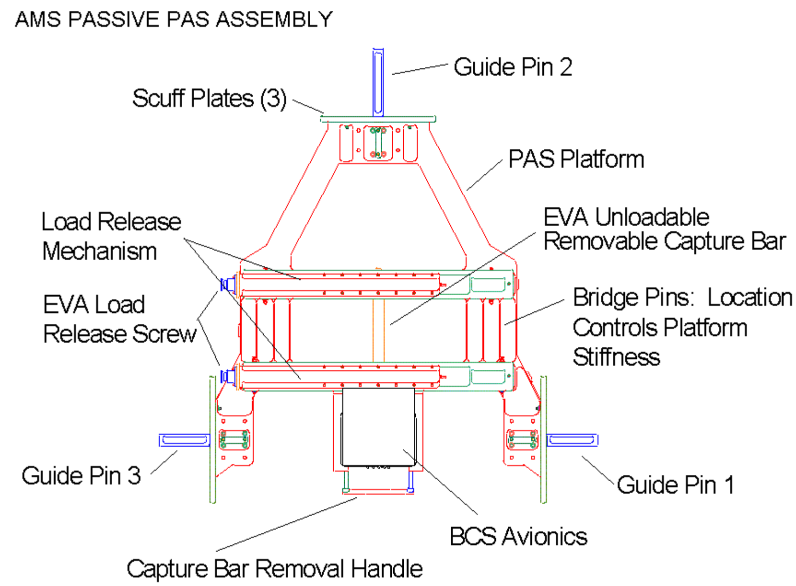
ISS Payload Attach Site



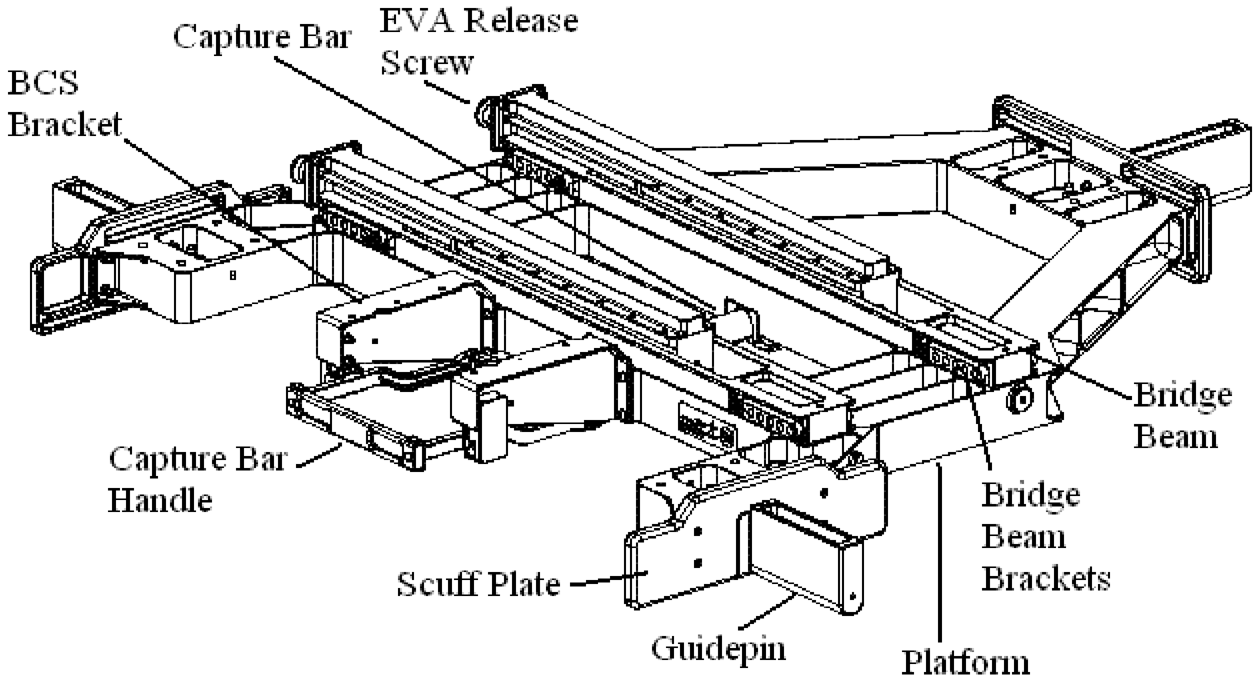
ISS Payload Attach Site



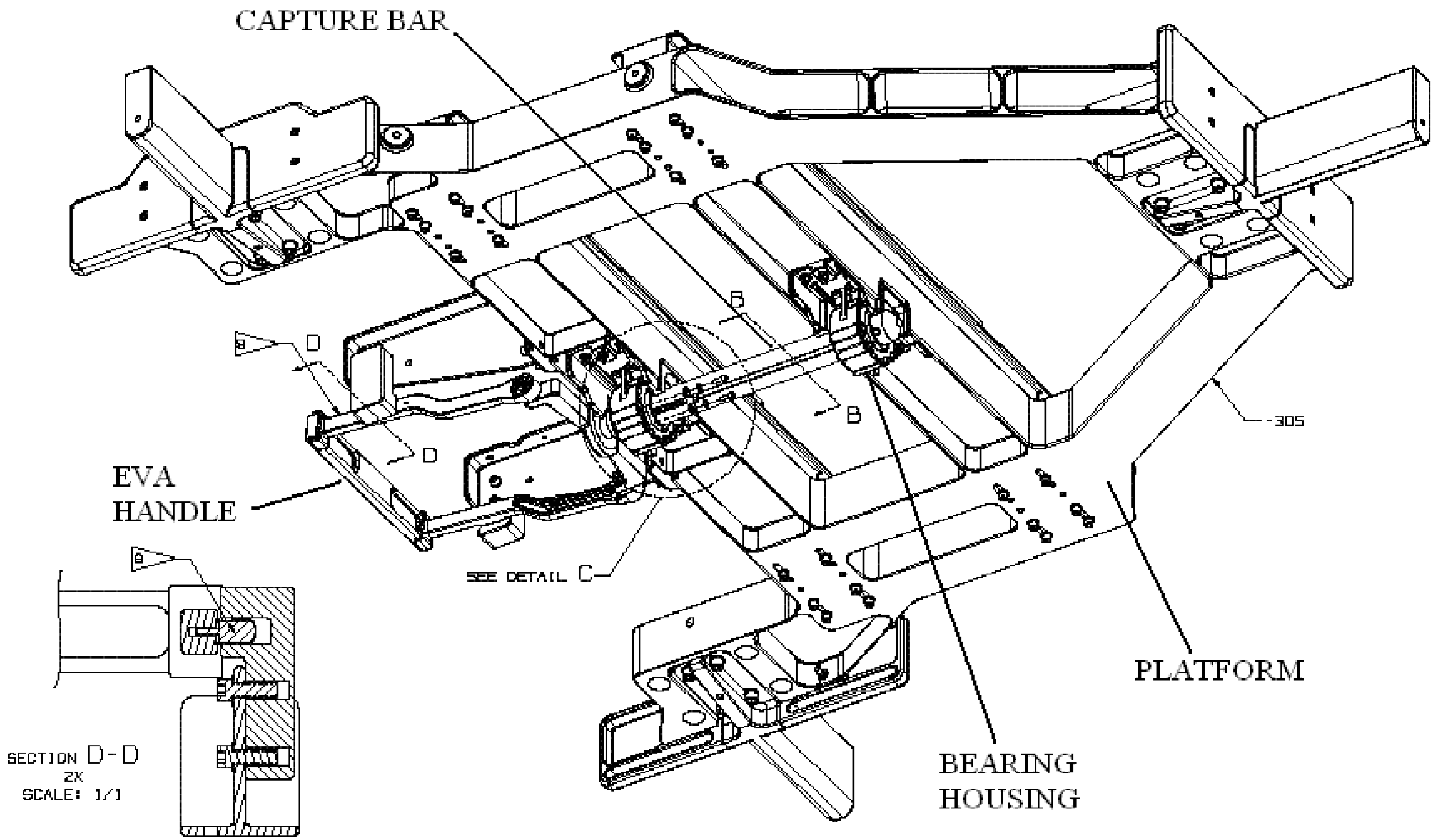
AMS-02 Interface to ISS Payload Attach Site



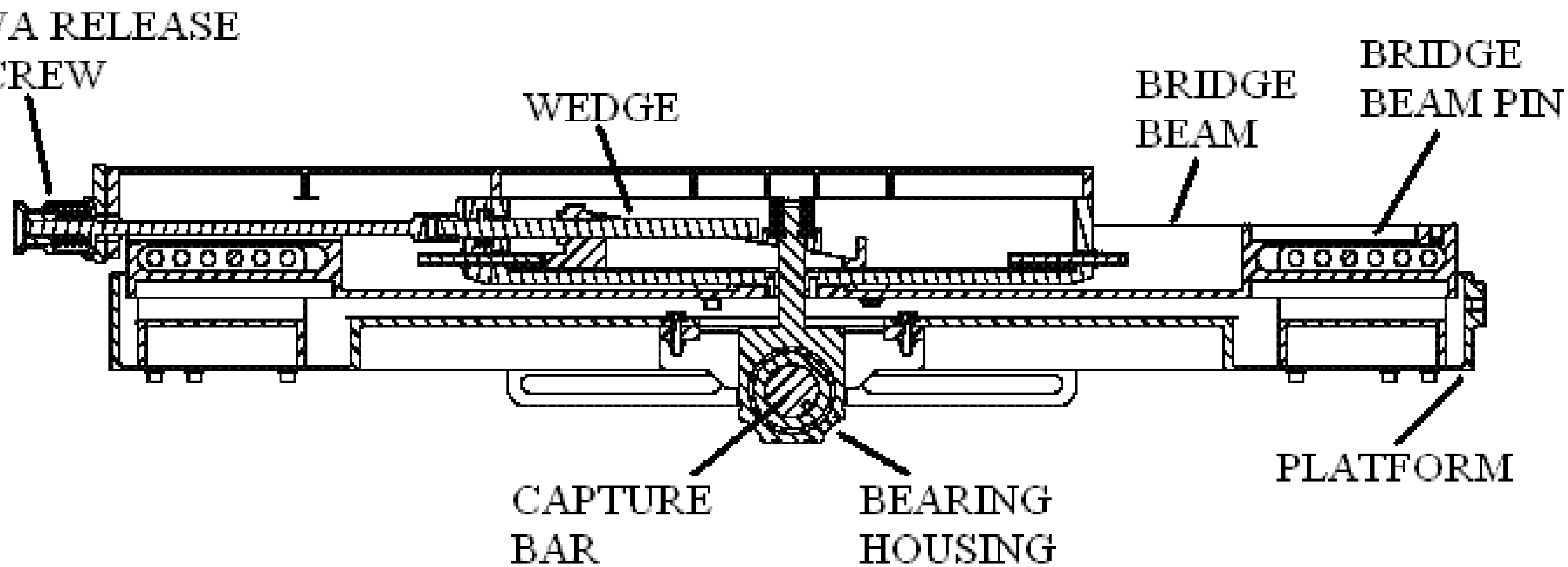
AMS-02 Passive PAS Assembly with EVA Release Mechanism



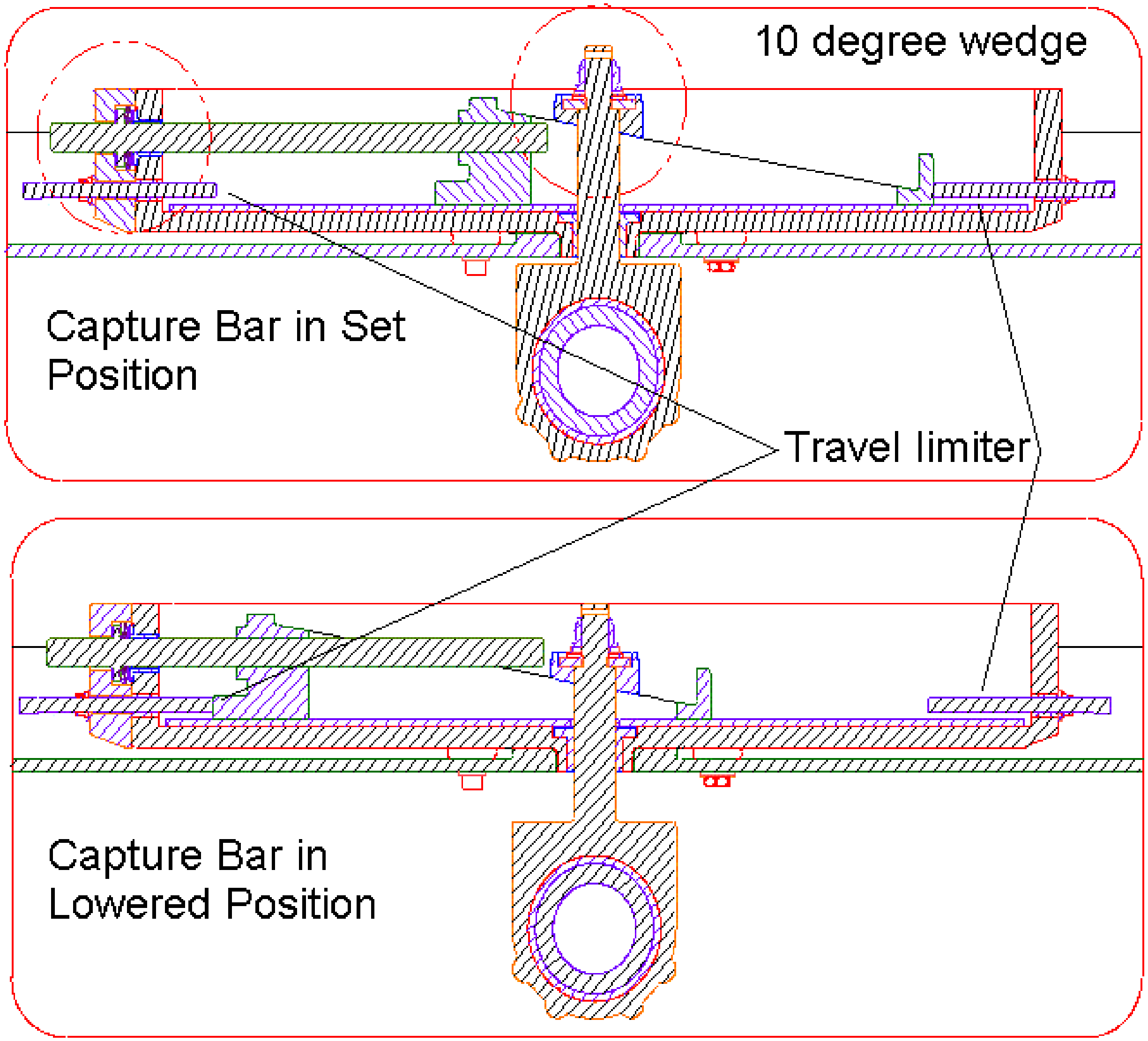
AMS-02 Passive Attach System with EVA Release Mechanism



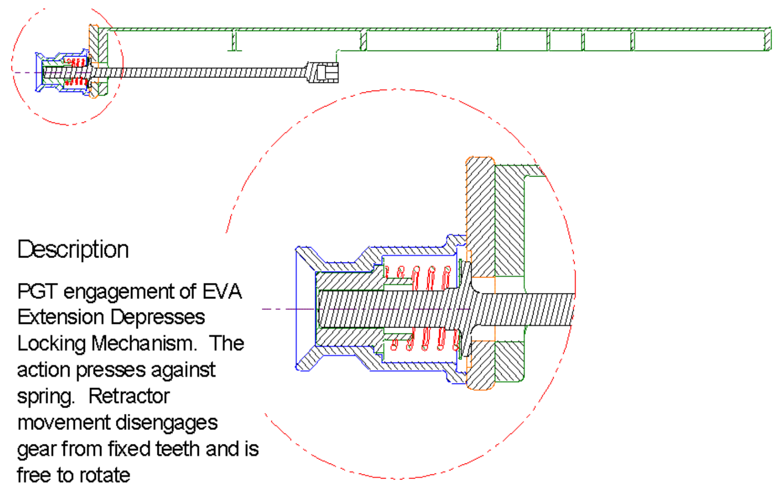
AMS-02 Passive Attach Mechanism with EVA Release Mechanism (View from ISS PAS)



AMS-02 PAS Preload Release Mechanism with EVA Release Screw



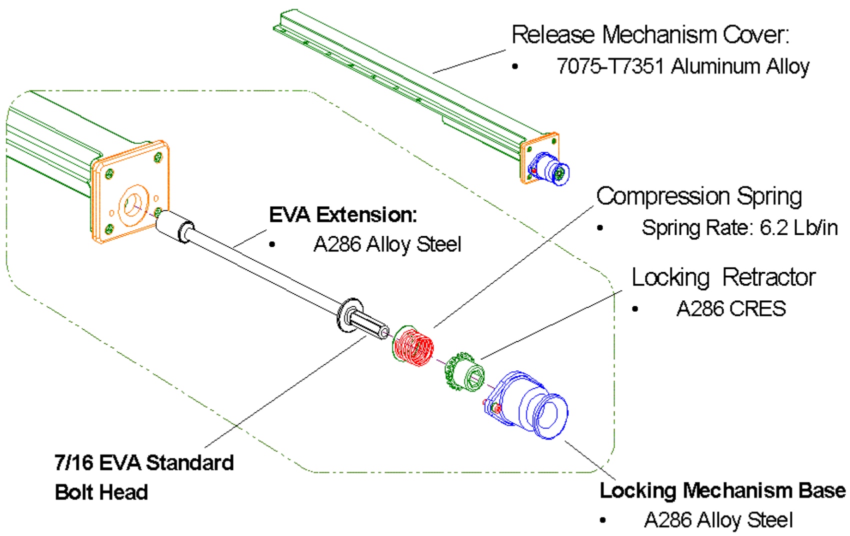
AMS-02 PAS Load Relief Wedge Operation



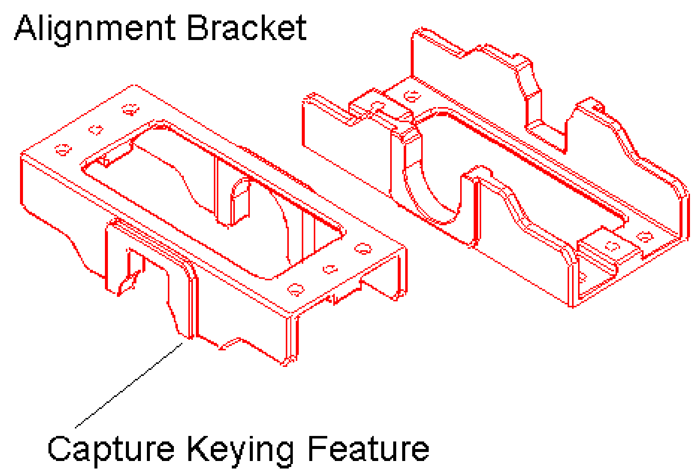
Description

PGT engagement of EVA Extension Depresses Locking Mechanism. The action presses against spring. Retractor movement disengages gear from fixed teeth and is free to rotate

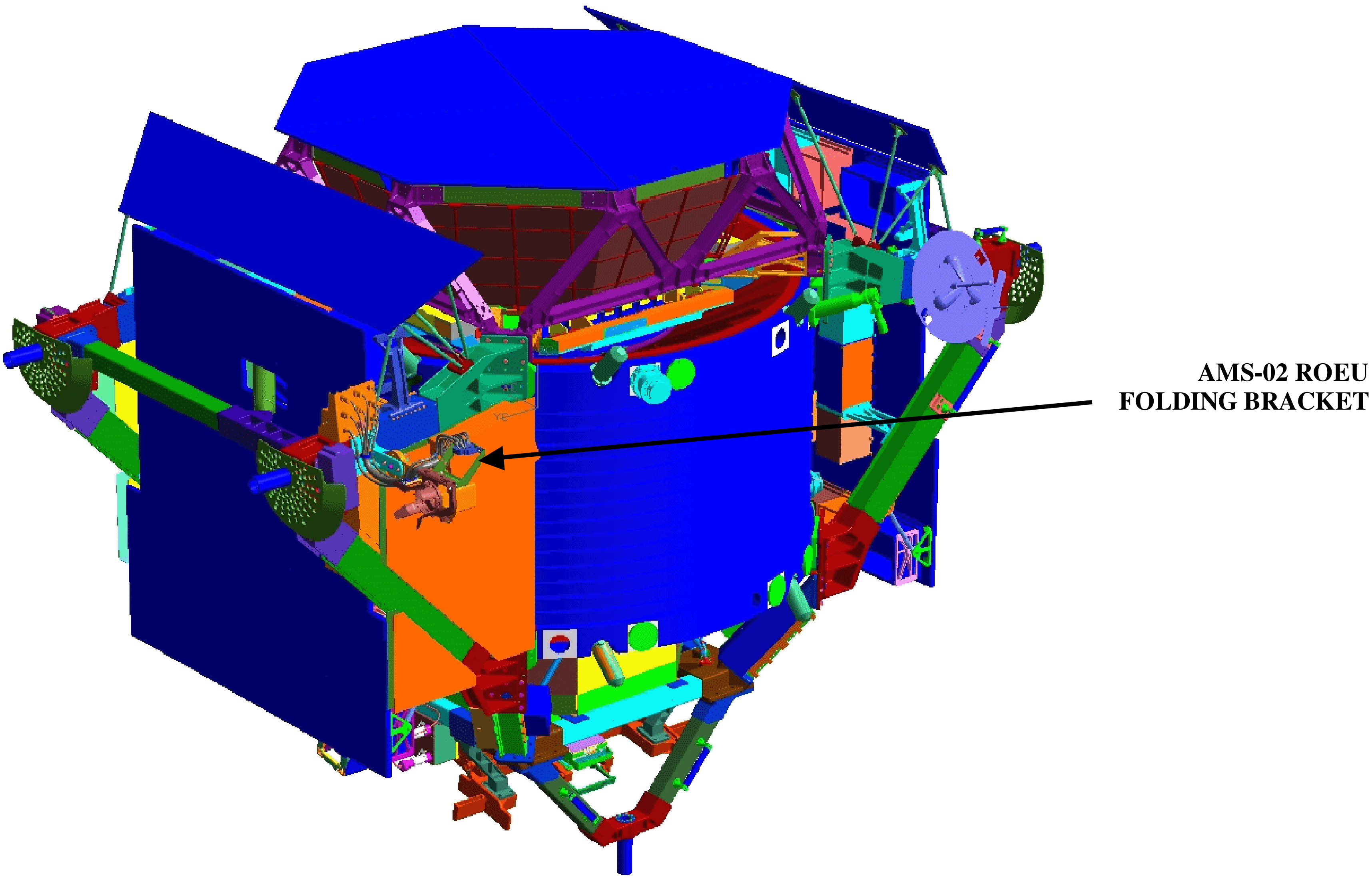
AMS-02 PAS EVA Release Screw Locking Mechanism

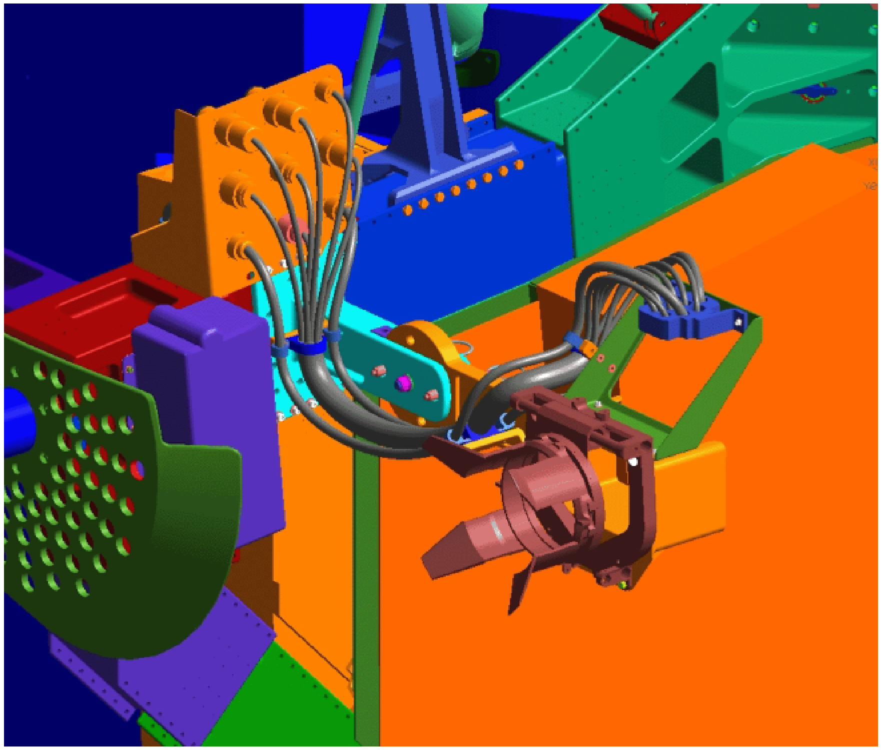


AMS-02 PAS EVA Screw Interface Design

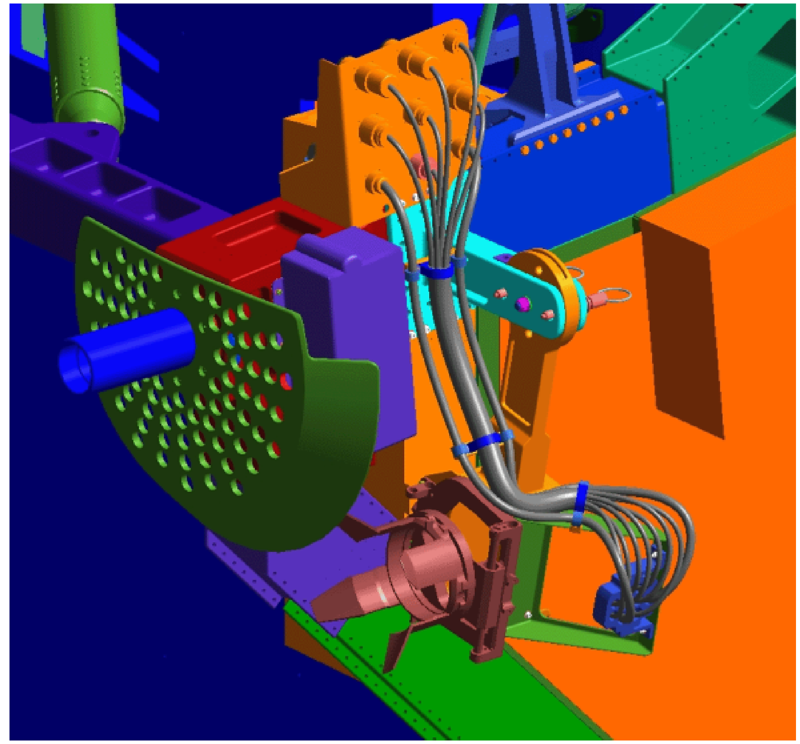


Capture Bar Capture Feature

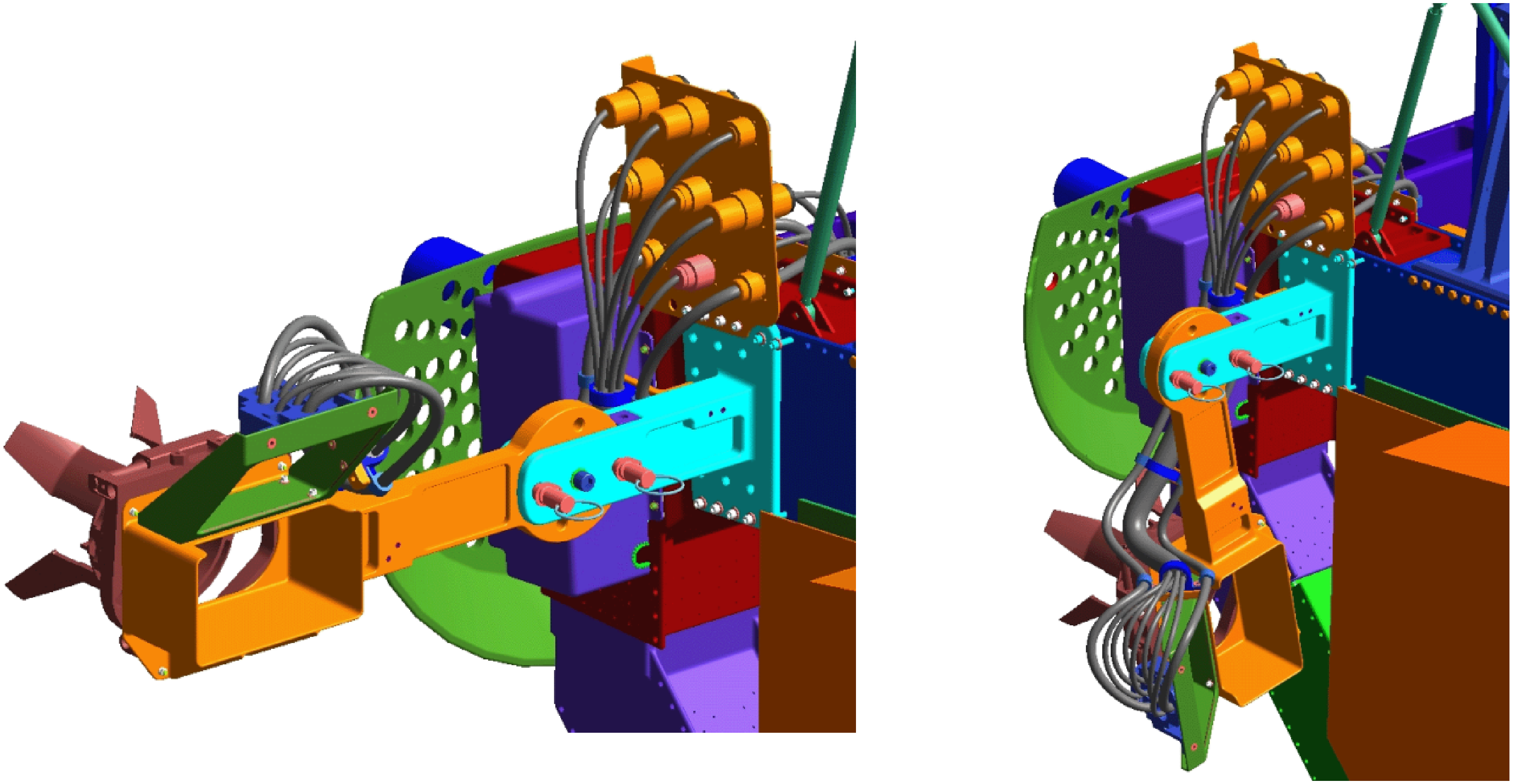

AMS-02 ROEU
FOLDING BRACKET



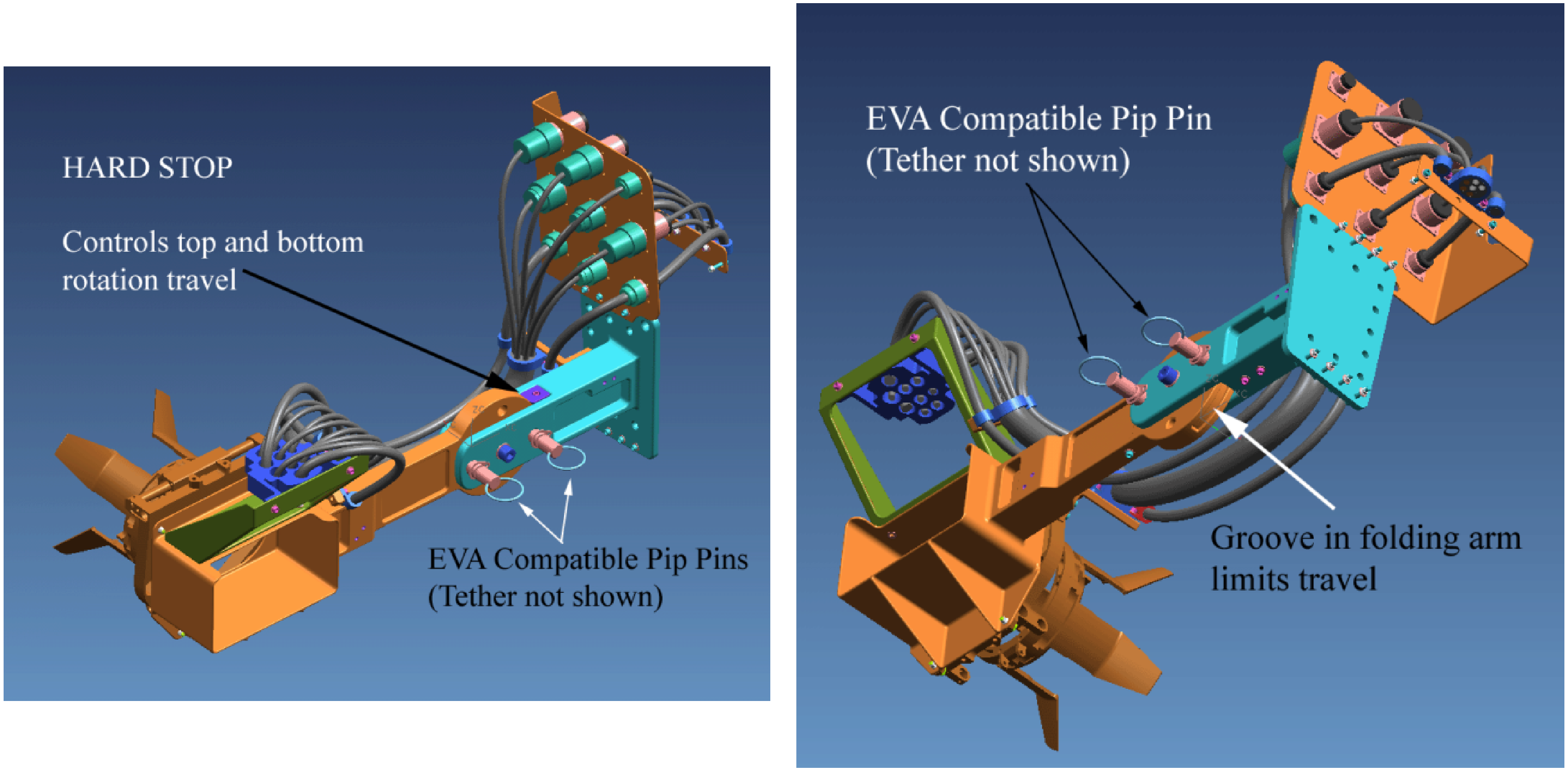
ROEU FOLDING BRACKET – LAUNCH CONFIGURATION



ROEU FOLDING BRACKET = FOLDED POSITION



ROEU FOLDING BRACKET – LAUNCH AND FOLDED POSITION – EVA COMPATIBLE PIP PINS



ROEU Folding Bracket Hardstop

TO: Robert Miley/OZ2	(281) 226-4968
NASA Contact: Larry Walter/ER3	(281) 483-5591
Analysts: John Bussell/MAGIK Team	(281) 244-7934
DATE: May 12, 2003	**Action Item #: 1705**
RE: AMS-02/ROEU PDA Clearance Assessment	
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The MAGIK Robotic Analysis Team has assessed the newest design configuration for the Alpha Magnetic Spectrometer (AMS) on the S3 truss. This memo documents the clearances between the AMS and the Express Pallet (EXP) installed to the neighboring S3 Payload Attach System (PAS). Similar analyses for previous AMS designs were examined in MAGIK action items 1110, 1146, 1174, 1192, and 1254. The most notable difference in this AMS design is the extension of the Remotely Operated Electrical Umbilical (ROEU) Payload Disconnect Assembly (PDA) by more than six inches. This extension is in the direction of the EXP on the S3 Outboard-Upper PAS and therefore impacts the clearance between the two payloads.

Assumptions:

- The AMS 3D CAD model was received from Ross Harold/Lockheed in May 2003.
- The AMS is installed to the S3 Inboard-Upper PAS.
- The EXP is installed to the S3 Outboard-Upper PAS.
- Since the EXP design is very preliminary, distance measurements were taken from the AMS model to the Attached Payload Envelope, as defined in SSP 57003, Figure 3.1.3.1.1.1-1.
- The distance (ISS +Y) from the center of the Inboard S3 PAS to the center of the Outboard S3 PAS is 113.38 inches
- This analysis addresses clearance issues by measuring distances between 3D graphic models. Areas not addressed in this document - lighting, viewing, EVA/EVR tasks, thermal and/or pressure effects on elements, and dynamics - could have a significant influence on the measurements and overall feasibility.
- 3D graphical models used in this analysis are a result of the MAGIK Team's "best efforts" to obtain/create accurate models reflecting actual volumetric dimensions of the various ISS elements. "Best efforts" include obtaining models directly from the ISS CAD Modeling Team, the hardware designers, or a 3rd party (a source other than the hardware designers), or creating models from hardware designer or customer provided drawings/information.
- Pedigree information for pertinent models may be obtained from the MAGIK Team upon request.

Figure 1 shows the AMS and EXP on the S3 upper attach sites. The red transparent envelopes shown in the picture represent the attached payload envelopes (SSP 57003). The best available model for the EXP is shown inside the outboard-upper envelope for reference. This figure shows that when both payloads are fully mated, the clearance between the AMS (specifically the ROEU) and the outboard payload envelope is 9.7 inches.

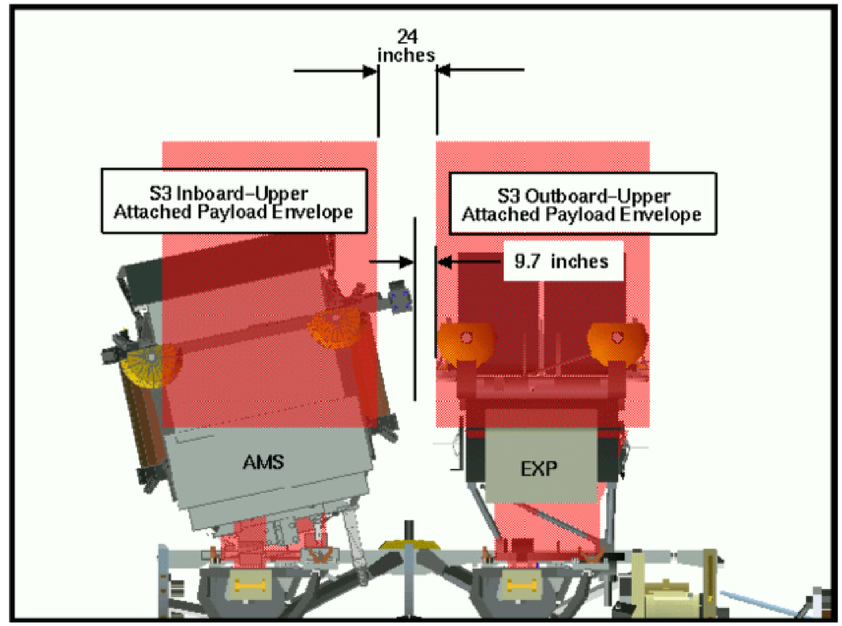

Figure 1: AMS and EXP Berthed to the S3 Truss – ISS Back View

Table 1 below lists the clearance between the AMS and the outboard payload envelope assuming the outboard payload is installed when the AMS is already present. The maximum misalignments used (2 degrees wobble, 2 inches lateral offset, and 2 degrees roll) were assumed based on input from MAGIK Action Item 1254 (previous AMS configuration analysis). Assuming the maximum misalignments, the clearance between the payloads is 1.5 inches when the incoming payload is nearly installed. The farther away from installation the payload is, the better the clearance to the AMS. With no misalignments, the clearance is 9.7 inches. Figure 2 and Figure 3 show the clearance between the AMS and the outboard upper envelope during the installation.

Table 1 – Clearance Between PAS Payloads

	Clearance Between AMS and Outboard Payload Envelope				
Distance Between Passive And Active Halves of PAS (inches)	**0, 0, 0 Misalignments** (Wobble, Lateral Offset, Roll) (deg, inches, deg)	**2, 2, 2 Misalignments** (Wobble, Lateral Offset, Roll) (deg, inches, deg)	**2, 0, 2 Misalignments** (Wobble, Lateral Offset, Roll) (deg, inches, deg)	**2, 2, 0 Misalignments** (Wobble, Lateral Offset, Roll) (deg, inches, deg)	**0, 2, 2 Misalignments** (Wobble, Lateral Offset, Roll) (deg, inches, deg)
0	9.7	N/A*	N/A*	N/A*	N/A*
4	9.7	1.5	3.5	4.2	5.1
8	9.7	1.7	3.6	4.4	5.1
12	9.7	1.8	3.8	4.5	5.1
16	9.7	1.9	3.9	4.6	5.1
20	9.7	2.1	4.1	4.8	5.1
24	9.7	2.2	4.2	4.9	5.1
28	9.7	2.3	4.3	5.1	5.1
40	9.7	2.8	4.8	5.5	5.1
50	9.7	3.1	5.1	5.8	5.1

* No misalignments are feasible if the payload is berthed to the PAS.

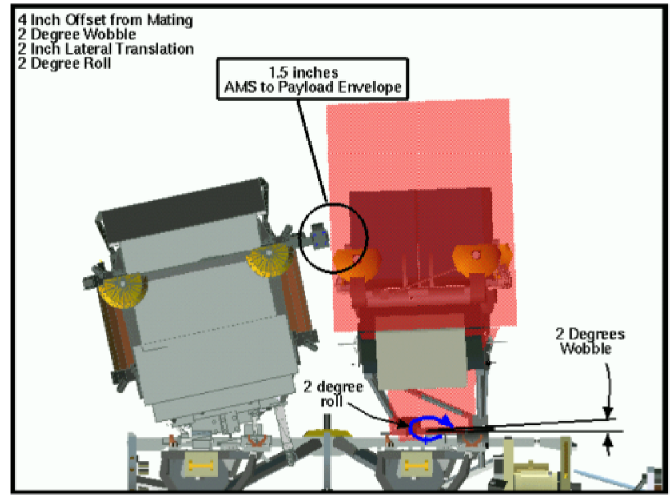

Figure 2: Clearance Between AMS and Outboard Envelope with Payload Misalignments ISS Back View

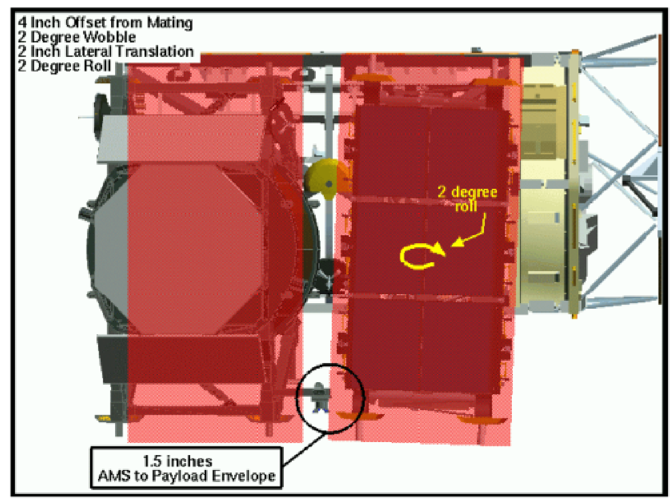

Figure 3: Clearance Between AMS and Outboard Envelope with Payload Misalignments ISS Top View

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